

Accrediting Complex M&S for an Analysis of Alternatives: A Successful Approach

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Purpose

This paper describes how Verification and Validation (V&V) efforts were considered and then assessed in the accreditation of the Modeling & Simulation (M&S) used in the GMTI (Ground Moving Target Indicator) Analysis of Alternatives (AoA). This discussion will bring the V&V community up to date with current accreditation guidance advocated by the Office of Aerospace Studies (OAS), the Air Force Center of Expertise for AoAs (Ref: AFI 10-601 13 Aug 99, §6.3.4) in accordance with the AFI 16-1001 and DoD 5000. The guidance and best practices that OAS has developed were particularly designed for developing the Verification, Validation, and Accreditation (VV&A) report for any AoA; however, the general approach could be adopted for other types of VV&A needs.

Accreditation “Theory”: Why we do V&V

AFI 16-1001, §12, states:

Accreditation is the official determination by the accreditation authority that the M&S is acceptable for a specific purpose. This determination considers the V&V status of a specific model version, its data support (source, quality, and VV&C) and the analysts/users that operate the model and interpret its results. The accreditation authority is the individual who is responsible and accountable for decisions or actions based upon the specific M&S usage. The decision to accredit a model or simulator rests solely with the accreditation authority. Likewise, determining the level of effort supporting a particular accreditation, whether conducting additional V&V activities or simply reviewing the existing M&S documentation and past VV&A history, rests solely with the accreditation authority. [Emphasis added]

Requirements

As one can surmise from this official definition, V&V plays an important part in the decision whether or not to use a particular M&S for a particular study. There is a choice of conducting new V&V activities or using past evaluations to determine model appropriateness. Thorough, well-documented V&V, including history of development and use, provides a strong foundation for an accreditation decision. The V&V Manager

provides this foundation (AFI 16-1001, §5). In practice, it is the Model Manager (acting as the V&V agent), who usually manages and maintains the V&V (Ref: AFI 16-1001, §15) and writes the V&V reports (Ref: AFI 16-1001, §8.4). The V&V documentation, including history and experience of use in past studies, combines to form an Accreditation Support Package (ASP) for the particular M&S. The ASP, in concert with the testimony of subject matter experts (SMEs), is then used by the Accreditation Authority to accredit the M&S for use in their study for their specific purpose. Simply put, accreditation is the determination that the M&S is “good enough” for the intended purpose of the analysis; for AoAs, this authority rests with the “owner” of the study (for the Air Force, usually the MAJCOM/DR).

The AoA accreditation process begins by looking for previous V&V efforts done for each of the models used. The accreditation decision is based on several criteria including history and experience of the M&S in consideration for use. The AoA activity itself also contributes to V&V efforts that should be documented in the accreditation report; it is this additional valuable V&V that evolves out of the analysis that has often been lost or poorly documented in past accreditations for AoA M&S. The GMTI AoA is capturing these V&V efforts to include them in the final Accreditation Report.

In AFI 16-1001, §11, we know that the V&V Agent has the responsibility to provide a V&V Report. The report, at a minimum, will:

- Specify M&S *reference* version number, plus all hardware and software identification or version numbers used in supplying model inputs.
- Identify model input data suppliers.
- Identify key V&V planning, technical review, and implementation participants or organizations, and their V&V responsibilities.
- Describe V&V methodologies, implementations, and their results.
- Describe verification, validation, and certification (VV&C) activities performed on input data sets used in V&V activities.
- Identify V&V criteria (MOEs/MOPs).
- Describe any additional model strengths, weaknesses, or limitations identified as a result of the V&V activity, with recommended remedial actions.

Some of these requirements were naturally considered in the GMTI AoA accreditation process for Phase I of the effort (pre-analysis stage). The rest of the requirements will be met by Phase II of the accreditation process (early 2003) as the models will then have been run and their output examined. Therefore, the AoA itself is a venue for a level of V&V to take place. Specific areas of model capability are examined that are appropriate for the AoA.

The V&V Report, combined with the M&S history maintained by the V&V Manger or delegated to be maintained by the V&V Agent, makes a strong ASP. With this information in hand, the Accreditation Agent (for AoAs, usually the Study Lead) must

write and submit an Accreditation Report to support the aforementioned accreditation decision (AFI 16-1001, § 12). At a minimum this report shall:

- Review the M&S development history, summarize past applications, and define its application domain based upon a description of capabilities by the M&S developer.
- Review the adequacy of the model's configuration version control and complete an acceptable face validation examination, if appropriate.
- Compare the M&S capabilities and credibility, based on V&V status, to the application criteria (See Tables 4.1 and 4.2). Assess risk of accepting M&S capabilities if they do not meet application criteria thresholds or have not had sufficient V&V.
- Ensure that model documentation exists and is current/sufficient for the intended use. This documentation will normally include the M&S conceptual model, user's guide, programmer's manual, and analyst's manuals.
- Ensure that data sources have been identified and both producer and user data VV&A activities were accomplished.

The GMTI AoA accreditation team evaluated these areas in the first phase of the process, which was conducted just prior to beginning the model runs. In the OAS guidance, additional criteria are evaluated in the accreditation decision beyond those listed above and in fact cover several of the requirements in the V&V report listed initially.

The V&V and Accreditation Cycle

As noted in the above requirements, both the V&V Agent and the Accreditation Agent have separate but related responsibilities, per AFI 16-1001. The V&V Agent creates the original V&V Report (for the V&V Manager) and combines that with the model use history to form the Accreditation Support Package (ASP). Funding for the original ASP is the responsibility of the DoD Component Head (AFI 16-1001 §4.4), though in practical terms this is usually taken out of the Model Manager's hide or simply done via working papers or testimony of programmers or subject matter experts. However, it is in the Accreditation Authority's best interest to have strong V&V for accreditation, so AFI 16-1001 §6.4 gives them the responsibility to fund additional V&V activities, if required, to make the M&S V&V acceptable for the particular study's purpose. These activities can take the form of additional documentation, but often include adding enhancements to the models as well. This additional V&V, any added enhancements, and the associated experiences in using the M&S for that particular study should be recorded and become part of the ASP, and thus the V&V report becomes more extensive for the next prospective user to look at using those M&S. Thus, the accreditation process can enhance the V&V for a particular M&S, and the V&V should become stronger in each cycle of use.

One of the goals of the AoA accreditation phases is to document V&V activities in parallel with the AoA. The GMTI AoA has begun that path.

Beyond the Requirements

When Study Leads conduct an AoA, they want others to believe the results. Since AoAs provide information to acquisition decision makers, the quality of the analysis is very important and often controversial. For dissenters to a study, there are two “easy targets” in almost any analysis: data and M&S. A properly executed accreditation process firms up these “soft spots”, and proper review of the M&S V&V and the analysis process to which the M&S are contributing are critical to this process. What constitutes “proper” review is the subject of this paper and is necessarily subjective depending on how contentious the subject is and what level of resources one has to devote to these assurances.

GMTI AoA Accreditation

What is an AoA?

An Analysis of Alternatives (AoA) is a study that is required for ACAT I or other special interest acquisition programs; it is part of the Concept Exploration phase of the acquisition cycle, and its purpose is to provide the decision maker an unbiased and accurate cost-effectiveness analysis of the systems that could be acquired to fulfill a mission need. The Office of Aerospace Studies (OAS) is designated in AFI 10-601 as the Air Force Center of Expertise for AoAs and is responsible for providing an independent assessment of Air Force AoAs to the Air Force Requirements Oversight Council (AFROC) or Joint Requirements Oversight Council (JROC). Since OAS assesses Air Force AoAs, they are usually invited to participate on the AoA Team in the role of independent advisor. OAS publishes and maintains the AoA Handbook, available on the OAS web page at <http://www.oas.kirtland.af.mil/>. It is periodically updated as the AoA process evolves to meet the emerging needs of the Air Force. OAS is actively assisting in the GMTI AoA and provided the accreditation process and facilitation role for the VV&A effort.

Introduction to GMTI

The Ground Moving Target Indicator AoA is a large Air Force study, co-led by AFSPC and AFC2ISRC, to provide insight into the acquisition of a system for sensing targets in a theater of interest. Over time the scope of GMTI expanded as more and more capabilities were being looked into, and therefore a large number of models were candidates for the analysis. The Effectiveness Analysis Lead formed a Model Review Committee with several of the major stakeholders in the AoA. They pared the number of models to be reviewed to twenty, and the Mission Task Leads responsible for analyzing one or two mission tasks then developed an initial analysis plan and chose the final twelve models selected for the accreditation review. A few other engineering level models were also used in the AoA M&S, and they were reviewed as input data sources. The primary focus for the accreditation was on the mission and campaign level models.

The GMTI AoA Accreditation Team (GAAT)

The GMTI AoA Accreditation Team (GAAT) was formed by the Study Lead to assist in the model review. The GAAT Team membership was drawn from the many organizations that formed the GMTI AoA Effectiveness Analysis (EA) Integrated Process Team (IPT), who were the study's primary stakeholders. Members included the AFSPC, ACC, AFC2ISRC, NRO, Army, Navy, and AFSAA representation. Representatives from these organizations were chosen by their command for their expertise in the modeling area and/or understanding of the missions modeled. Each organization had a vote in the assessment of the criteria towards accreditation. There were 17 to 19 voting members on the GAAT, depending on their availability over the three-day term. The GAAT also included model advocates/modelers that were not given a "vote" for the assessment but could, through their sponsoring stakeholder organization, voice their concerns and, more importantly, answer questions posed to them by the GAAT regarding their models. This large interdisciplinary GAAT membership was created to thoroughly address the concerns of the accreditation authority regarding the models to be used in the GMTI AoA effectiveness analysis, as well as to provide a credible review of the analysis process.

In the execution of the review, other benefits to the quality of the AoA surfaced. The GAAT meeting was the first time all the modelers gathered together to work out the details of the M&S plan. The GAAT voiced several questions that assisted the AoA M&S team in formulating solutions to areas that had not yet been investigated. Areas of contention were discussed openly, as the GAAT was an ideal forum for addressing important issues to the analysis process.

Up Front and Early

The GAAT, on the advice of OAS, implemented some lessons learned from previous AoAs. The Accreditation Process would include two phases. Phase I would occur before the analysis had begun to examine the analytical plan with regard to the model's capability and would investigate the appropriateness of the M&S to be used. The intention of the accreditation effort is to consider the analytical plan before beginning the analysis. However, the AoA teams in the past had a tendency to do the accreditation work near the end of the AoA, after it is too late to change the way the M&S is used or make any improvements (through V&V results). Some reasons for the late start are that the Study Leads are typically pressed for time and sometimes charge into the analysis without full preparation. There are also budget constraints, and sometimes there is simply a lack of guidance on how to accredit the M&S until the analysis had already started. Additionally, a good reason for later review is that much more information (from model runs) is available to give a better assessment of the model capabilities and limitations. Thus, doing some amount of the M&S first is beneficial for better understanding of the M&S process. The GMTI AoA was the first AoA to take a methodical look at the M&S and the way it was to be used *before* the analysis began, and thus they addressed many problems before they occurred and thus enabled study resources to be better focused on the areas of higher risk noted in this process. The Phase I assessment also serves as a forcing function to pull disparate ends of analysis together and to polish the linkages to make the analysis run smoother. A report was written at this

stage called the GAAT Phase I Report, and it was submitted to the Study Directors to be approved by the Accreditation Authorities.

Something New: A Second Accreditation Report and Model Linkages

There are two parts to V&V in AoA M&S. Phase I includes an initial assessment of the V&V and possibly assignment of resources to address concerns. There is also a need for addressing the V&V following the model and simulation runs. These additional requirements are often discovered when examining the model outputs during the analysis. Thus, the Accreditation Process in the GMTI AoA now includes a Phase II mid-course Risk Assessment -- a new concept in AoA VV&A. Note that the Phase I report actually satisfies the requirements denoted in AFI 16-1001. As discussed previously, the reason for Phase II is that there is much more to learn from conducting VV&A following the model runs. Even after the M&S and analysis plan are approved, there are still unexpected complications or concerns that will naturally crop up during the analysis. For phase II the GAAT will meet again at least once more to reassess the risk inherent in the analysis based on what has actually occurred by this time and will take into consideration additional insights that are only possible to gain by *doing* the analysis. They decided to meet before the end of the analysis (with time and resources available) in order to be able to redirect resources into areas for risk mitigation. The results of the AoA will then be reported along with a description of the risk management used in the process to obtain those results. The phase II GAAT report will then be incorporated into the AoA Final Report.

Another important concept added to the AoA M&S accreditation effort is to examine model linkages among models used for the analysis. AoAs typically use several models together to answer the questions of effectiveness for weapon systems. Prior to this new approach, accreditation teams only considered models individually; now we consider the whole architecture and the interactions among models. We assessed the model linkages by first determining which models contributed to which questions or Measures of Effectiveness (MOEs) in the analysis design. Once that schematic was mapped out, we looked at the quality or expected quality of the interfacing between the models for each MOE. Thus, the MOEs were given a rating that corresponded to the set of interfaces that it was required to pass through. The criteria that are listed in the next section only pertain to Phase I of the accreditation effort. More strict criteria will be used in Phase II.

Accreditation Assessment Methodology

The AFSPC Space Analysis Center (ASAC), as one of the leads for the GMTI AoA effectiveness analysis, co-chairs the GAAT with the Office of Aerospace Studies, which plays the role of facilitator, advisor, and independent consultant. While the GAAT was formed from EA IPT stakeholders, the GAAT reports (Phase I and II) are delivered to the Accreditation Authority (AFSPC/DR) for signature, and as such the GAAT has responsibility directly to AFSPC/DR to give as clear and unbiased a report as possible.

The GAAT met 9-12 April 2002 at Kirtland AFB, NM. The Office of Aerospace Studies facilitated this working meeting, and network support for a collaborative and anonymous work-stations were provided by AFOTEC. Collaborative work environment software was used to facilitate discussion and record the GAAT commentary and decisions. The software was very useful as it provided an anonymous forum to encourage honest discussions, and the interface was setup for adhering to a tight schedule. It was also the primary method for documentation of the discussion and made writing the Accreditation Report much more efficient.

The assessment methodology used at the April 02 meeting implemented the criteria in Table 4.1 *Accreditation Criteria for Assessing Model V&V*. This listing meets the minimum accreditation assessment requirements for M&S as outlined in AFI 16-1001. The first four criteria are critical M&S assessment drivers. That is to say, a 'red' in any of these four areas should warn the accreditation authority that the model should not be used, or requires improvement.

The GAAT also assessed the interrelationships of models used to analyze the MOEs. Table 4.2 *Criteria for MOE-Model Linkage Assessment* describes the evaluation criteria for linkages. Each MOE was given an overall score consolidating the linkages that were expected to derive the MOE results. The rollup of the linkage scores provided a High (Green), Medium (Yellow), or Low (Red) confidence in obtaining the required MOE.

These discussions captured the strengths and weaknesses of the output/input linkages among the data sources and models. Using their understanding of the model interrelationships, the GAAT assessed the expected capability of the outputs of the models to yield the MOE results.

The GAAT is composed of representatives and stakeholders in the GMTI AoA, including Mission Task Leads and representatives from the Army and Navy. Model representatives were on hand to support the Mission Task Leads and to answer questions. The resident expert briefed the models to be used in this AoA. These briefers provided a self-assessment with rationale for their scores with respect to this AoA (Appendix A contains those briefs). The GAAT then discussed each of the nine V&V assessment criteria in table 4.1 for each model. Following the collaborative discussions every member of the GAAT submitted a vote with rationale for their rating of each criteria. In the event of a vote result indicating a 50-50 or 40-60 split, the conservative rating was taken. If the vote was 2/3 or more, the majority ruled with dissenting comments included for the reader.

The VV&A report for phase I was reviewed by the GAAT. The AFSPC/DR Technical Director certifies the final draft of this report and the AFSPC/ASAC makes the necessary staffing arrangements to prepare for the accreditation briefing to AFSPC/DR.

Table 4.1 Accreditation Report Criteria for Assessing Model V&V

Criteria	Rating Scale
Risk: Assess the analysis for: 1) Timely and accurate representation of the natural environment 2) Authoritative representation of human behavior 3) Authoritative representation of the subject(s).	(Red) Model not appropriate for intended purpose. Do not use for this study.
	(Yellow) Relevant model of Environment/Behavior/System
	(Green) Demonstrated adequacy for intended purpose.
Input Data: Assess the input data used to describe the three representation listed above	(Red) Data are arbitrary or best guess. Data not reviewed.
	(Yellow) Most data are traceable to certified sources. Data Reviewed.
	(Green) All data are valid/certified/pedigreed..
Critical Elements Modeled: Compare the M&S's capability to the application criteria. Can the model address the inherent issues associated with the MOEs?	(Red) MOE functionality not modeled
	(Yellow) Functionality indirectly contributes to the MOE, or offline analysis required.
	(Green) MOE functionality directly modeled
User Experience: Assess the experience, credibility and capabilities of the AoA analysis team.	(Red) Model user has no modeling experience, nor prior expertise with this model.
	(Yellow) Model user has limited expertise with this model.
	(Green) Model user has expertise with this model, or is the developer.
History: Review the M&S development history, summarize past application(s), and define its application domain based upon a description of the capabilities by the M&S developer (AFI16-1001)	(Red) No history; new model
	(Yellow) Some history, primarily undocumented. Well documented lineage
	(Green) Lineage completely documented
Configuration Management: Review the adequacy of the model's configuration version control; and complete an acceptable face validation examination, if appropriate (AFI16-1001)	(Red) No formal configuration management process
	(Yellow) Some configuration management process for all major upgrades/code changes.
	(Green) CCB process for all changes
Documentation: Ensure that model documentation exists and is current/sufficient for the intended use. This document will normally include the M&S conceptual model, user's guide, programmer's and analyst's manual(s) (AFI16-1001)	(Red) No published documentation
	(Yellow) Published documentation for previous version; change documentation developed but not published
	(Green) Complete set of documentation exists for version used
User Community: Compare the analysis with known US and international analysis standards and techniques	(Red) Limited user community for specialized applications not related to current usage
	(Yellow) Small user community; no formal user's group.
	(Green) Formal user's group representing wide range of applications
Prior V&V: Ensure that data sources have been identified and both producer and user data VV&C activities were accomplished (AFI16-1001)	(Red) - No prior V&V
	(Yellow) Some V&V studies conducted on previous version. Face validations exist for current usage.
	(Green) Well documented V&V including live test results and/or model comparisons; prior accreditation reports

(Source: AFMC/OAS AoA Handbook 2000)

Table 4.2 Criteria for MOE-Model Linkage Assessment

Criteria	Rating Scale
MOE-Model Linkage:	(Red) Linkage has not been demonstrated and model representatives do not know how it will work: Unknown Linkage
	(Yellow) Linkage is expected to be reasonable between the models by model representatives: Expected Linkage
	(Green) Linkage or interface between models has been done before: Demonstrated Linkage

The Way Ahead

The GMTI AoA is currently conducting model runs and will soon be ready for Phase II of the Accreditation Process. For Phase II, The GAAT, along with the EA IPT lead, should monitor the analysis and keep informed of the V&V efforts and the progress of the analysis. Ideally, the whole GAAT should have regular meetings throughout the M&S to stay current. The exact format of the GAAT Phase II Risk Assessment/Management Report is still unknown, as it will need to be unique to address concerns more specific to this particular AoA. As this AoA progresses OAS will incorporate the lessons learned from it to refine the next AoA’s accreditation process. One consideration that OAS advises study directors to think about is that the Accreditation Plan may be included in the Study Plan for the AoA and maintained as a living document. This would allow for the V&V to be documented continually as part of the scheduled plan updates. An important lesson learned is there is no “one” way to conduct the accreditation for AoAs due to their uniqueness. Other insights will undoubtedly be gained as this process continues, and the most up to date guidance can be found by contacting OAS; contact info and published guidance can be found on the OAS web page at <http://www.oas.kirtland.af.mil/>.

Conclusion

V&V is an integral part of performing large accreditation of large studies such as AoAs. We have discussed some techniques and methodologies that OAS recommends that allow for the variation in Air Force AoAs. It is hoped that this paper may give the reader some insight into the regulatory requirements of VV&A, and also how those requirements may be considered together through this new two-phase accreditation process to enhance analysis and provide a case for stronger V&V efforts by both model manager and model user.

Appendix 1: Mapping the Requirements

We begin our mapping process from the top, DoD Directive 5000.59, “DoD Modeling and Simulation (M&S) Management”, 4 Jan 94. This Directive replaces the "Modeling and Simulation Management Plan," June 21, 1991, and the "Establishment of the Defense Modeling and Simulation Office (DMSO)," July 22; establishes DoD policy, assigns responsibilities, and prescribes procedures for the management of M&S; establishes the DoD Executive Council for Modeling and Simulations (EXCIMS); and establishes the Defense Modeling and Simulation Office (DMSO). Consequently, DoDI 5000.61, 29 Apr 96, “DoD Modeling and Simulation (M&S) Verification, Validation, and Accreditation (VV&A)” was then written to implement this directive.

DoDI 5000.61 is the basis on which our VV&A Policy rests. It charges the Heads of the DoD Components to establish policies, procedures, and requirements for VV&A and to provide resources to accomplish it. This document also sets forth the DoD-level requirements for documentation of VV&A (V&V §6.4, Accreditation §6.5). For each of the each of the three parts of this process (Verification, Validation, and Accreditation), it requires identification of the agent responsible; description of the M&S version/release and developing organization; complete identification and description of methodologies, organizations, and individuals involved; and recording of the results of these efforts, to include identified M&S limitations. It further identifies that V&V is the responsibility of the M&S proponent (developer), while Accreditation is the responsibility of the M&S application sponsor (i.e. the user).

These requirements are further refined in AFI 16-1001, 1 Jun 96, Verification, Validation, and Accreditation (VV&A). Briefly here: this document gives the responsibilities of all parties involved, from HQ USAF to MAJCOM/FOA/DRU to the more familiar V&V Manager, V&V Agent, Accreditation Authority, and Accreditation Agent responsibilities. The overall single point of contact for the Air Force regarding VV&A issues is the Directorate of Modeling, Simulation, and Analysis (HQ USAF/XOM). This organization deals with issues such as cross service or non –DoD agency coordination. At the MAJCOM level, a POC is appointed to deal with V&V issues and activities. Also, the MAJCOM establishes a V&V Manager for each command-owned or managed M&S, and is tasked to provide resources to meet V&V management requirements within the command. The V&V Manager manages the whole V&V effort for the particular M&S, including maintaining a repository of V&V documents, and model use history, planning and executing an M&S V&V Plan, and refining any legacy M&S into compliance with V&V standards in an incremental fashion as possible. The V&V Agent, usually the Model Manager or Developer, is also sometimes the V&V Manager. The V&V Agent serves as a source of expertise to the Accreditation Authority, makes a plan to address deficiencies in V&V, performs all V&V activities, and prepares the final V&V report for submission to the Accreditation agent and the V&V Manager. The Accreditation Authority is responsible for reviewing the accreditation reports and sorting documentation from the accreditation agent. Also, it is responsible for approving, funding, and monitoring all V&V activities that are directly supporting the upcoming accreditation decision. The Accreditation Agent serves as a

source of advice and expertise for the Accreditation Authority, prepares the accreditation report, and otherwise assists the Accreditation Authority in making the accreditation decision.

The Office of Aerospace Studies (OAS) gives guidance on the use of VV&A in AoAs. This guidance incorporates the above directives and instructions, but also adds additional suggestions according to the lessons OAS has learned in their long history of assisting with AoAs. OAS publishes and maintains the AoA Handbook, which is available on the OAS web page at <http://www.oas.kirtland.af.mil/> and is periodically updated as the AoA process evolves to meet the emerging needs of the Air Force. The accreditation process described in this paper is the cutting edge of our AoA experience, and is currently undergoing review to be included in an expanded VV&A section of the AoA Handbook.